## PHYSICS AND ENGINEERING AT THE McGILL UNIVERSITY, MONTREAL.

So long ago as 1855, Sir William Dawson pointed out the importance to the McGill University of a department of practical science. But though some attempt was made to carry out the suggestion, little success was obtained until 1878, when the department was constituted a Faculty of Applied Science, with Prof. H. T. Bovey as Dean. The Faculty passed through many vicissitudes, but it was placed on a firm basis at the beginning of last year, by the opening of well-furnished workshops and laboratories equipped with the best and most modern apparatus for scientific investigations in all kinds of engineering and physics. A description of the opening ceremonies has lately been published in a souvenir volume, together with descriptions of the main features of the laboratories. We are indebted to this volume for the following information, and to Dean Bovey for the accompanying illustrations.

The McDonald Engineering Building, erected and equipped through the munificence of Mr. W. C. McDonald, one of the Governors of the University, is a fine structure containing laboratories for all branches of engineering work. The Physics Building owes its existence to the generosity of the same donor. It has been designed for the teaching and study of physics (including mechanics) with special regard to (1) its intrinsic importance as an integral part of a liberal education in the Faculty of Arts; (2) its essential necessity as a study preliminary to the courses of engineering, mining, and practical chemistry in the Faculty of Applied Science, and (3) the prosecution of scientific research. The completeness and liberality with which all the necessary plant has been put into these buildings may be judged from the accompanying illustrations and brief descriptions. It will astonish the various authorities who have similar technical institutes under their control in this country, to know that the cost of the equipment alone of the two buildings came to very nearly one hundred thousand pounds sterling! Compare this princely generosity with the fact that only twenty-three thousand pounds were asked for to erect and equip the Engineering Laboratory of the University of Cambridge. The exact amount of Mr. McDonald's benefactions has not been told, but they are certainly nearer seven than six figures. Everything, in fact, required in the pursuit of physical and engineering study has been lavishly provided. Few occupiers of chairs of Physics here are in the fortunate position of Prof. Cox. He was instructed to spare no expense in obtaining everything required to carry on work in experimental physics. "From first to last," he says, "whether it was a question of part of the buildings or of the equipment, I have heard no other language from Mr. McDonald than 'Let us have everything of the best, with a definite aim for everything, but always the best.'"

The Thermodynamic Laboratory (Fig. 1), in which heat engines are studied, has a very notable equipment.

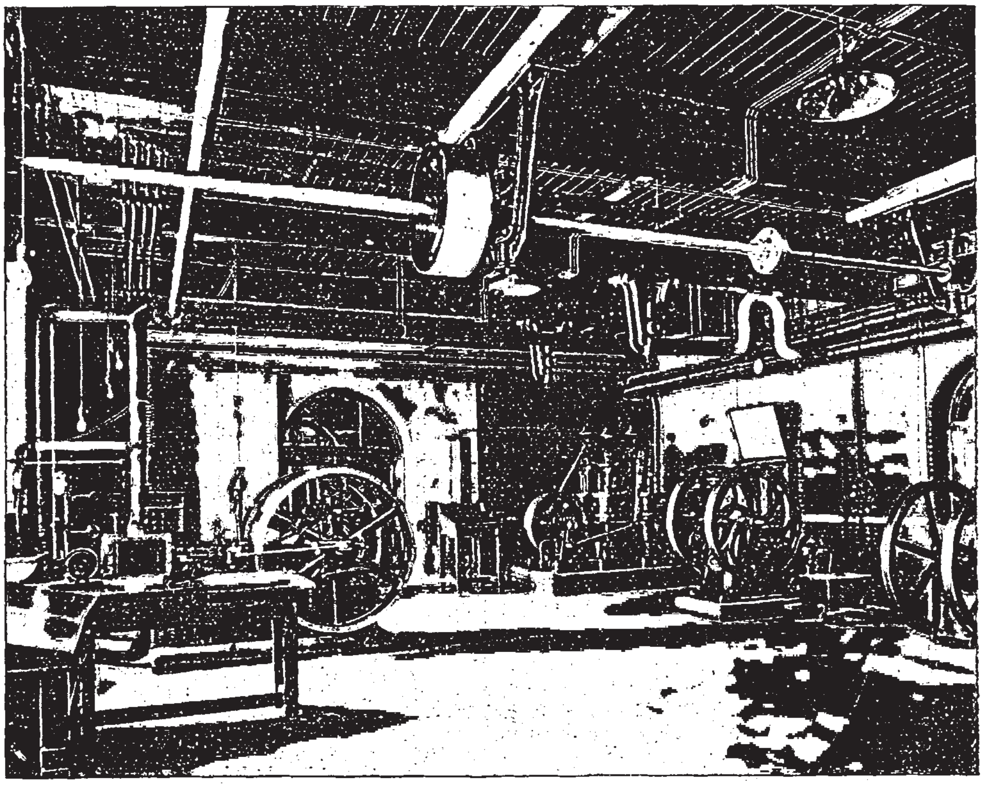


Fig. 1.—Thermodynamic Laboratory.

The great feature of interest is a four-cylinder steam engine arranged double tandem fashion, and intended for use in a large number of totally different ways. This machine, designed by Messrs. Schonheyder and Druitt Halpin, of London, under the general direction of Prof. Carus-Wilson, of McGill College, was manufactured by Messrs. Yates and Thom, Blackburn.

The engine may be described as a double tandem inverted direct acting quadruple expansion engine, to work at 200 lbs. pressure on the gauge, developing eighty horse-power at about 150 revolutions. The two engines may be uncoupled from each other, and run at different rates of speed on the plan proposed by Mr. John I. Thornycroft, and already carried out on the triple expansion engines at the Owens College, Manchester; and in this way the advantages of variation of relative cylinder volume are to some extent obtained.

The measurement of the power delivered to the brakes is made by means of hydraulic brakes of the types designed by the late R. E. Froude, and improved by Prof. Osborne Reynolds.

The steam pipes about the cylinders are so arranged that the engines may run either quadruple, triple, double, or single expansion. And as the pipes are led both to condenser and atmosphere, all these types may be tried either condensing or non-condensing.

In fact, a complete balance-sheet of the heat supplied, used, and rejected by the engines can be made, and the materials for the study of cylinder condensation by Hirn's analysis are easily obtained.

Several other engines and boilers are available for experimental purposes.

The Third-year Laboratory contains apparatus for the demonstration of the properties of the permanent gases and of steam; and a complete set of the most modern types of pyrometers and thermometers, gauges, mercury columns, planimeters, calorimeters, render possible investigation of many problems of importance to the engineering world.

In the third year, students of thermodynamics are taught the principles of the science by direct experiment; and original research is encouraged during the summer under the direction of the professor.

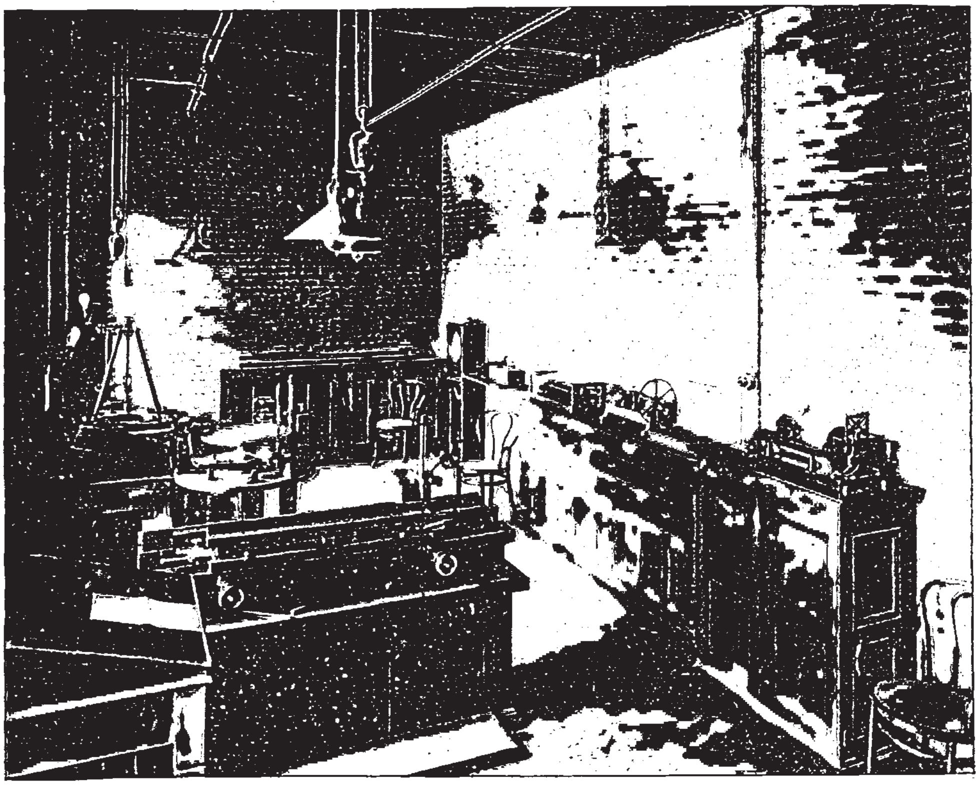


FIG. 2.—Geodetic Laboratory.

In the fourth year, engine boiler and fuel testing is largely worked at; and the higher parts of the subject are explained by reference to the results obtained from the indicator card, as measured and examined for moisture and heat exchange. The gas and hot-air engines are tested again and again, and the effect of the different factors which modify results pointed out by careful observation.

The Geodetic Laboratory (Fig. 2) is primarily designed for the investigation of apparatus used in geodetic and surveying operations; it also affords the means of producing standards of length and of graduating circles.

The laboratory is double-walled, and the inner wall, which is of brick, contains an air space. In the basement there is an air chamber, from which hot or cold air may be supplied to the work-room by a system of pipes. The air circulation is maintained by a fan which is driven by an electro-motor at any required speed. When the desired temperature is reached all openings are closed, and a practically uniform temperature held for many hours. The instrumental equipment consists of comparators, dividing engines; a portable Bessel's reversible pendulum, for the determination of gravity; an astronomical clock, break-circuit chronometer and chronograph; level triers, end-measuring gauges, and minor instruments.

The equipment of geodetic and surveying instruments for the use of students consists of transits and transit theodolites of various forms, levels of the Dumpy Wye and precision types, sextants for marine sounding and land work, plane tables of English and American forms, surveyors and prismatic compasses, current meters, an altazimuth for triangulation work, a zenith telescope, astronomical transits.

There are also hand levels, chains, steel bands, tapes, barometers, pedometers, and other minor instruments required for geodetic work.

The Mathematical Laboratory (Fig. 3) is liberally supplied with apparatus with which the student learns to make measurements of time, mass, distance, acceleration, and other quantities dealt with in the lectures, as well as to verify the fundamental laws of mechanics and to investigate various mathematical and dynamical constants. Special attention is directed to the general principles underlying the ordinary instruments of precision which are used in physics, the simpler forms of these instruments being put into the hands of the student at an early period in his course. The experiments are in almost all cases quantitative, and the learner is encouraged to attain the greatest possible precision which the nature of the experiment and the instruments available admit.

The Electrical Engineering Laboratories are under the care of Prof. C. A. Carus-Wilson. They consist of the magnetic laboratory, the electrical laboratory, the dynamo room and the photometer room.

The equipment in the magnetic laboratory comprises a ballistic galvanometer designed for use in a variable magnetic field (this can be connected with any apparatus in this room or in the dynamo room); a calibrating coil for the galvanometer, two magnetic yokes, a solenoid and spring balance for traction experiments up to one hundred pounds, fitted with search coil for ballistic tests; Ewing's magnetic curve tracer; round and rectangular bobbins for experiments in self-induction; a secohmmeter, telephones, rheostats, &c., and a set of secondary cells.

The electrical laboratory is situated over the dynamo room. Slate slabs are let into the wall on three sides of the room, and stout wooden tables placed down the centre. Current is supplied to all parts from the dynamo room. The apparatus here comprises a Thomson galvanometer, three Kelvin electrostatic voltmeters, two Siemens dynamo-meters, four d'Arsonval galvanometers, seven Weston ammeters and seven Weston voltmeters of different ranges, two Weston alternating wattmeters, two Kelvin balances, one of which is specially arranged for testing transformers; two Cardew voltmeters, several other ammeters and voltmeters of different types, standard cells, resistance boxes, rheostats, &c. All tests of transformers are carried on in this laboratory, the current being brought up from the dynamo room below.

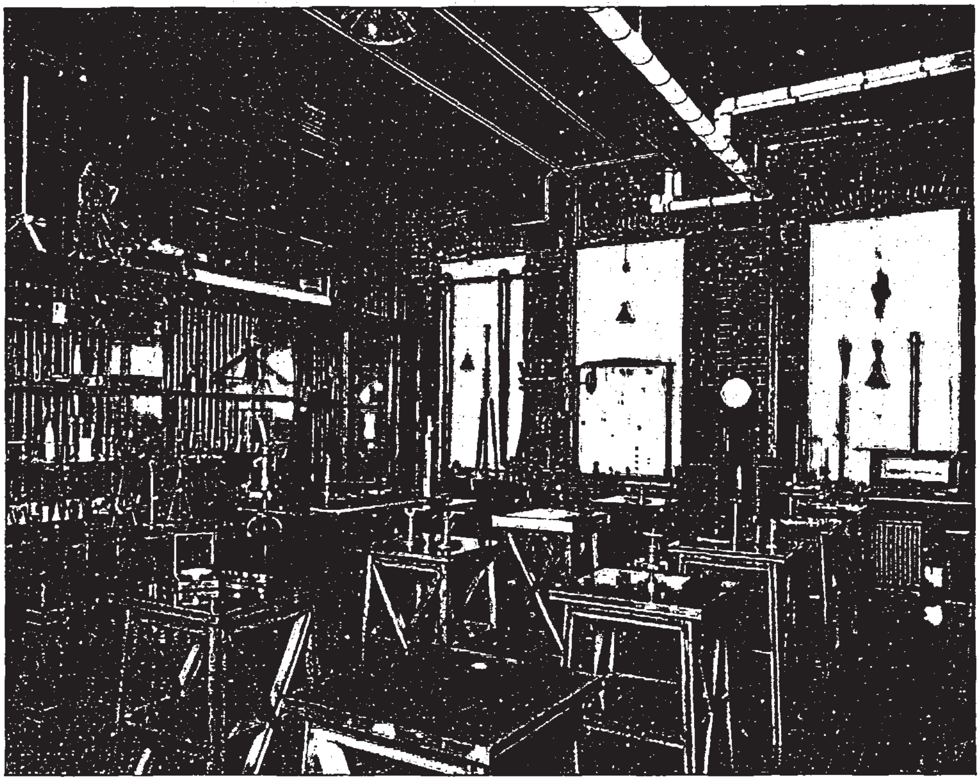


FIG. 3.—Mathematical Laboratory.

The dynamo room is on the ground floor. In one half of the room are placed the lighting, in the other the experimental dynamos. The *Lighting Dynamos* consist of a Siemens dynamo and an Edison-Hopkinson dynamo, each of 30 kilowatts output at 105 volts, and each driven by a 60 horse-power Willans engine. The building is wired on the three-wire system, but can be run by either one of the dynamos when the load is light, or by a set of secondary cells of 800 ampere hours' capacity placed in another room. The lighting switch-board was made in the electrical workshop, and is fitted with Weston station ammeters and voltmeters. The *Experimental Dynamos* are driven off a main shaft either by a 90 horse-power MacIntosh and Seymour engine, or by a 25 k.w. Edison motor, as is most convenient. The main shaft is provided with ten magnetic clutch pulleys of 20 horse-power each, designed and fitted at the college, and with one magnetic clutch-coupling for 90 horse-power; the dynamos comprise two 12 k.w. Edison dynamos, a 7 k.w. Victoria Brush dynamo, a 6 k.w. Thomson-Houston arc light dynamo, a 7 k.w. Fort Wayne dynamo, a 5 k.w. Brush arc light dynamo, a 7 k.w. Victoria Brush motor generator, a 15 k.w. Thomson-Houston incandescent dynamo, a 5 horse-power Crocker-Wheeler motor, and several smaller motors of different types; also a 12 k.w. Mordey alternator specially made for this laboratory (the armature coils can be moved through any angle, and two or three currents of any phase difference thus obtained). There are in the building at present eight motors driving lathes, fans, &c., besides a 10 horse-power electric elevator. The dynamo room also contains several transformers, arc lamps, &c., and a set of five enamel rheostats, each of which can be made to carry from 1 to 50 amperes on 100 volt circuit.

The photometer room is furnished with a Bunsen photometer and a Methven standard, and is specially arranged for testing incandescent lamps.

These four laboratories are supplemented by an *Electrical Workshop* containing a fine lathe, by the American Machine Tool Company, driven by an electric motor.

The work in the Electrical Engineering Laboratories is commenced in the second term of the third year. By that time the students have gained a fair general acquaintance with electricity in the physical laboratory. They then begin a series of experiments on electricity and magnetism, using methods and instruments in ordinary practical use, confining their attention, however, to principles and not to their practical application. This term's work is preparatory to that of the fourth year, when students study the practical application of these principles in the dynamo room. Here they make experiments on electrical machinery of all kinds, and carry out tests of dynamos, transformers, motors, &c., under practical working conditions. They can also see a typical lighting station at work, and become familiar with the best practice and design in all branches of electrical engineering.

The practical instruction in the workshops is solely designed to give the student some knowledge of the nature of the materials of construction, to familiarise him with the more important hand and machine tools, and to give him some manual skill in the use of the same. For this purpose, the student, during a specified number of hours per week, works in the shops under the direct superintendence of the Professor of Mechanical Engineering, aided by skilled mechanics. The courses commence with graded exercises, and gradually lead up to the making of joints, members of structures, frames, &c., finally concluding in the iron-working department with the manufacture of tools, parts of machines, and, if possible, with the building of complete machines.

The machine shop and engine room (Fig. 4), an extremely good equipment, including twelve metal lathes for the special use of students, one large centre lathe, planing, shaping, universal milling, drilling and tapping machines, and all necessary centering and grinding machines. The shop, which is also used for fitting, contains seventeen vices and a very complete assortment of tools. All the machinery consists of types selected from the best manufacturers in England and America.

The hydraulic laboratory contains a tank twenty-eight by five by five feet square, perfectly flush on the inside, and specially designed for investigations as to the action of water under low pressures. The tank is provided with specially designed valves and gauges, which do not interfere in the slightest degree with the stream-line flow, and by means of which variations in pressure in different horizontal sections and under different conditions of flow, can be observed with accuracy. The tank has also fixed to it a recording hydraulic gauge, which has been designed to make one, two, four, eight, or twenty-four revolutions in a specified time. The tank discharges into a water-course about forty feet long and five feet wide. This course may be divided up into one, two, or more compartments, each compartment being carefully calibrated so that the amount of the discharge can be easily estimated. At the end of the course, provision is made for inserting weirs of various forms and dimensions. Over these weirs the water flows into large measuring tanks, which have been carefully calibrated, and each of which has a capacity of about 250 cubic feet. The volume by weight of water in each of these, or in all the tanks, may be observed at a glance by means of an indicator on the wall of the laboratory. Experimental work under high pressures up to 150 lbs. per square inch is rendered possible by a connection with the high-level reservoir of the city. By means of a stand-pipe with special fittings for pipes, nozzles, valves, &c., investigations can be made under any pressure from zero up to the maximum. Any desired head may be kept constant by means of a water-pressure regulator, designed for this laboratory. Pipes from six inches in diameter downwards, can also be led from this stand-pipe for a distance of about sixty feet, so that experiments on the frictional resistance to the flow of water in pipes can be carried out under varying pressures. Another special feature of this laboratory is an impact machine, designed by Prof. Bovey, for measuring the power and investigating the efficiency of water-jets in combination with buckets of different forms and sizes. The laboratory is also to have a set of pumps specially designed for experimental work and research. These pumps are to be adapted to work under all pressures up to 120 lbs. per square inch, and at all speeds up to the highes found practicable, with valves of the best kind and proportions. The equipment of the laboratory also includes a Venturi water-meter, water-meters of other kinds, gauges and gauge-testers, and in fact all the apparatus necessary for the scientific investigation of the properties of water and water-meters, and all kinds of hydraulic apparatus.

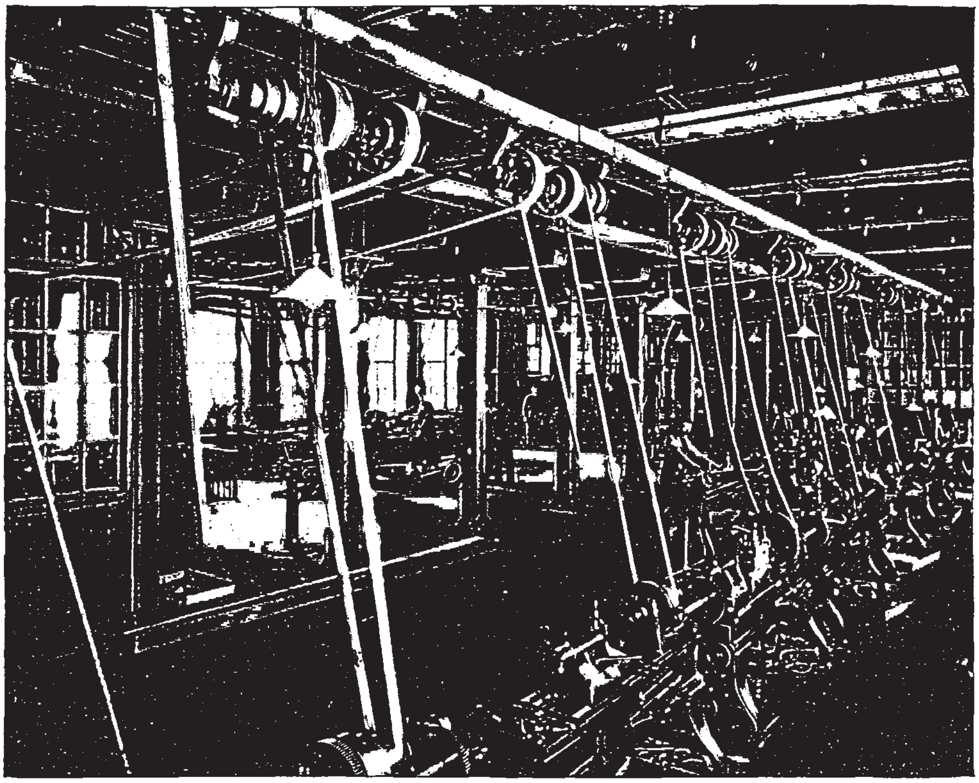
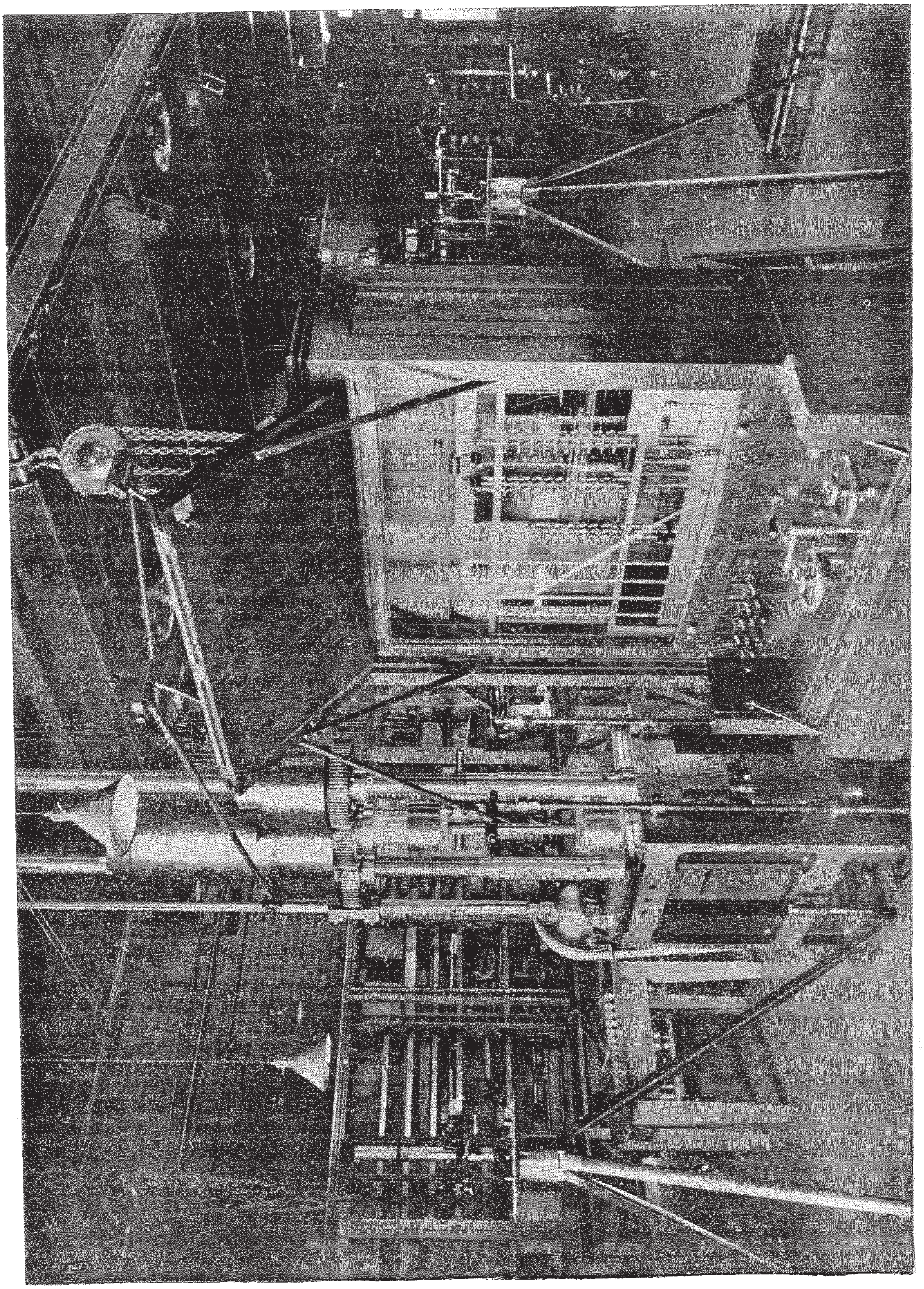
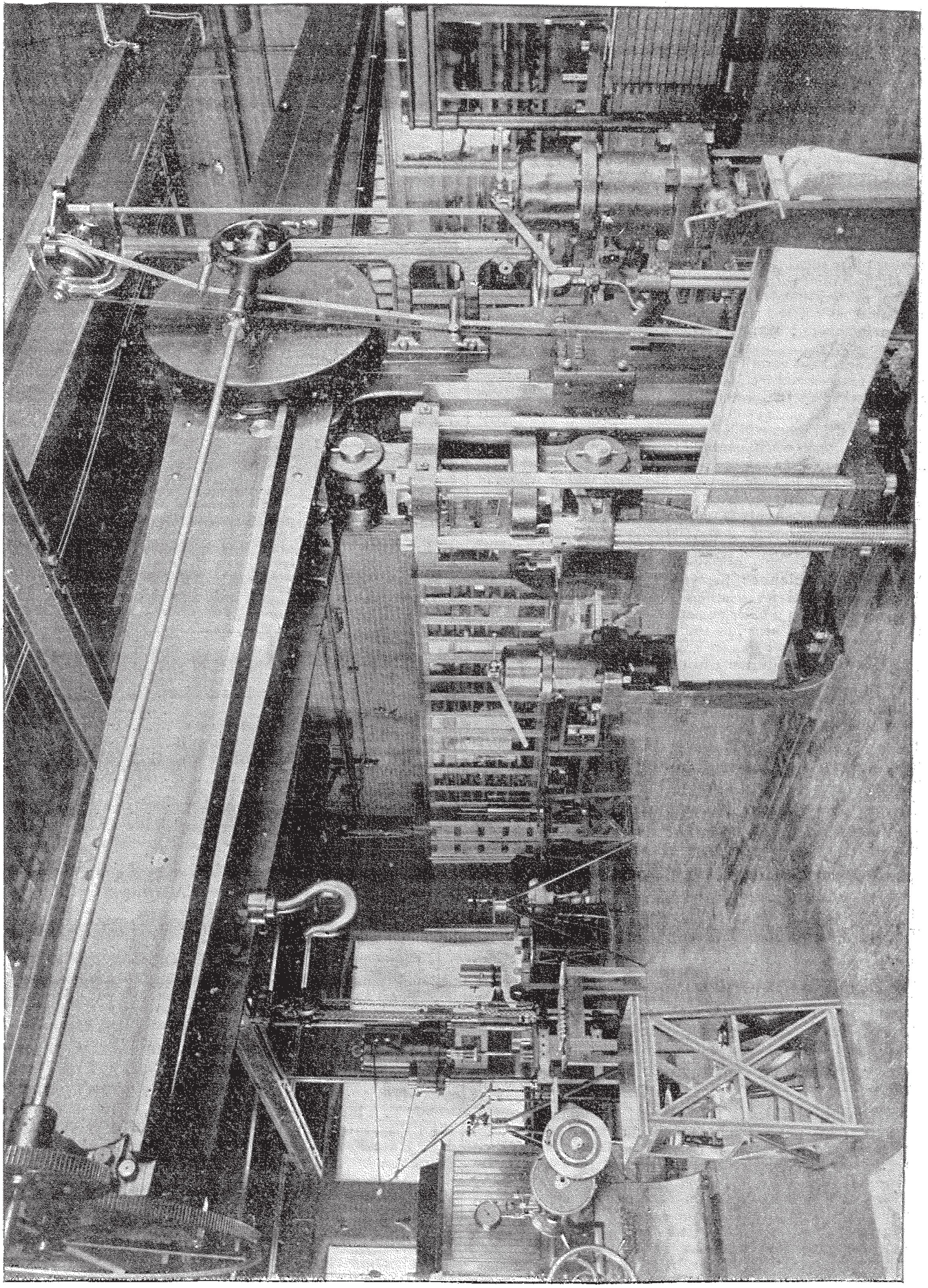


FIG. 4.—Machine Shop.

The main apparatus in the testing laboratories (Fig. 5) consists of a 75-ton Emery testing machine, with a capacity for tension specimens up to 66 in. in length, for compression specimens up to 85 in. in length, and for transverse tests up to 60 in. between bearings; a 100-ton Wicksteed testing machine (Fig. 6), with a capacity for tension specimens up to 72 in., for compression specimens up to 48 in. in length by 10 in. square; an Unwin testing machine for torsional, transverse, and tensile testing; an angle cathetometer (this instrument was specially designed and elaborated for the testing laboratory by Messrs. Nalder Bros., under the direction of Prof. Bovey, to enable





accurate measurements to be made in connection with the use of horizontal types of torsion testing machines, and also to measure any deflections of a pointer moving about a horizontal axis, through an angle not exceeding 180°); a cathetometer, specially designed for the testing laboratory.

An impact machine is being constructed, fitted with revolving drum, tuning-fork, &c., for recording deflections under rapidly repeated blows. With the aid of this apparatus valuable results may be expected from tests carried out upon materials subjected to repeated stresses.

In the laboratory there are also an Oertling bullion balance with a capacity up to 125 lbs. and down to 1/100 of a grain, and standard weights up to 100 lbs.; a Muir lathe, a shaping machine, and a grinding machine are provided, so that all the apparatus required for preparing the specimens for testing is at hand.

In addition to the above, the laboratories are supplied with numerous other small pieces of apparatus, amongst which may be mentioned Whitworth's measuring machine for measuring a variation of one-hundred-thousandth of an inch, Sweet's measuring machine, and a very complete and elaborate collection of micrometers, vernier calipers, caliper squares, depth gauges, rules, &c.

Our space will not permit us to give an adequate description of the laboratories and lecture-rooms which the McGill University owes to the benefactions of Mr. McDonald and Mr. Thomas Workman, and the mere enumeration of the experimental apparatus contained in them will raise a spirit of envy in the minds of the many workers whose expenditure on scientific instruments is curtailed within very narrow limits. Certain it is that these magnificent donations have provided Montreal with a school of practical science unsurpassed in its facilities for learning.

## *SOCIETIES AND ACADEMIES.*

### Paris.

Academy of Sciences, September 24.—M. Lœwy in the chair.—Geodesy and its relations with geology, by M. H. Faye. Gravity has a greater numerical value in islands than in the midst of continents, as the constant is determined by pendulum observations; this is probably due to the more rapid cooling of the crust of the earth beneath extensive seas, as evidenced by the low temperature of water (1° or 2°) at depths at which the temperature is about 133° in land. The greater average density owing to the lower temperature accounts for the higher value of the constant at sea, notwithstanding the replacement of so much solid matter by the specifically lighter water. The author then draws attention to the need of aid from geologists in the further elucidation of the reasons for variations in the constant of gravity.—Truffles (Domalan) from Smyrna, by M. A. Chatin.—M. A. Pomel accompanies a copy of his "Monographie des Bœufs-Taureaux fossiles des terrains quaternaires de l'Algérie" by a brief note on its contents.—Experimental researches on the influence of low temperatures on the phenomena of phosphorescence, by M. Raoul Pictet. Substances showing strong phosphorescence after exposure to sunlight entirely lose this property on strongly cooling (say to −100°), but regain their power on being allowed to approach the ordinary temperature in the dark without further exposure to light. The time during which this *potential luminosity* may be retained, at temperatures such that most of the energy of heat vibrations is abstracted, is now being investigated.—Observations of the sun, made at Lyons Observatory with the Brünner equatorial, during the second quarter of 1894, by M. J. Guillaume. The distribution of spots and faculæ during April, May, and June is given in tabular form.—On the rotation of solar spots, by M. Flammarion. The observed rotations of spots on themselves in several cases are all in the same sense from south through west to north, and amount in one case to 77° in three days, in another to 152° in four days, and in a third case the rotation reaches 34° in two days. This law of rotation is not, however, applicable to cases where segmentation occurs.—On the theory of the Wimshurst machine, by P. V. Schaffers. It is shown that a small modification of the Wimshurst machine enables its efficiency to be doubled, and the reasons leading to this modification are discussed.—On the coexistence, in the same host, of a monosporous coccidian and a polysporous coccidian, by M. Alphonse Labbé.—On the function of the kidney in Helix, by M. L. Cuénot.—On the alimentation of two commensal organisms (*Nereilepas* and *Pinnotheres*), by M. Henri Coupin.

## BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Books.—A Shilling Arithmetic: J. Hamblin Smith (Longmans).—Memorials of Old Whitby: Rev. Canon Atkinson (Macmillan).—Timber and Timber-Trees: late T. Laslett, 2nd edition (Macmillan).—A Text-book of Pathology: Prof. D. J. Hamilton, Vol. 2 (Macmillan).—An Introductory Account of certain Modern Ideas and Methods in Plane Analytical Geometry: Dr. C. A. Scott (Macmillan).—General Report on the Operations of the Survey of India Department during 1892-93 (Calcutta).—Apparitions and Thought-Transference: F. Podmore (Scott).—The Senile Heart: Dr. G. W. Balfour (Black).—A Text-Book of Statics: W. Briggs and G. H. Bryan (Clive).—A Text-Book of Dynamics: W. Briggs and G. H. Bryan (Clive).—Régularisation des Moteurs des Machines Électriques: P. Minel (Paris, Gauthier-Villars).—Fortification: E. Hennebert (Paris, Gauthier-Villars).—Durham College of Science Calendar, Session 1894-95 (Reid).—Rain-making and Sunshine: J. Collinson (Sonnenschein).—Spiritual Law in the Natural World: J. T. Thomas (Longmans).—Merchant Venturers' Technical College, Calendar, Ninth Session, 1894-95 (Bristol).—La Géographie Littorale: J. Girard (Paris, Société d'Éditions Scientifiques).—Badminton Library—Archery: C. J. Longman and Colonel H. Walrond (Longmans).—Lithogenesis der Gegenwart, Dritter Theil; Einleitung in die Geologie als Historische Wissenschaft: Prof. J. Walther (Jena, Fischer).—Lehrbuch der Vergleichenden Anatomie: Vierte Abthg. Vergleichende Anatomie der Echinodermen und Enteropneusten: Dr. A. Lang (Jena, Fischer).—Ways and Works in India: G. W. MacGeorge (Constable).—The Theory of Sound: Lord Rayleigh, Vol. 1, 2nd edition (Macmillan).—Tenth and Eleventh Annual Reports of the Bureau of Ethnology to the Secretary of the Smithsonian Institution (Washington).—The Nests and Eggs of Non-Indigenous British Birds: C. Dixon (Chapman).—Astronomie Sferica: Prof. Porro (Roma, Società Editrice Dante Alighieri). The New Technical Educator, Vol. iv. (Cassell).—Nomenclator Coleopterologicus: S. Schenkling (Frankfurt a/m. Bechhold).—New South Wales, Report of the Minister of Public Instruction for the Year 1893 (Sydney, Potter).

Pamphlets.—Thesis for the Degree of Doctor of Science of Edinburgh University, on the Relative Efficiency of certain Filters for Removing Micro-organisms from Water: Surgeon-Major H. H. Johnston (Edinburgh, Banks).—Report on the Relation between Malarial Fever among Her Majesty's White Troops at Port Louis, Mauritius, and the Meteorological Elements of Temperature, Rainfall, and Relative Humidity for the Year 1889: Surgeon-Major H. H. Johnston (Edinburgh, Banks).

Serials.—Royal Natural History, Vol. 2, Part 11 (Warne).—Zeitschrift für Physikalische Chemie, xv. Band, 1 Heft (Leipzig, Engelmann).—Timehri, June (Stanford).—Schriften der Naturforschenden Gesellschaft in Danzig, Neue Folge, Achten Bandes Drittes und Viertes Heft (Danzig).—Sunday Magazine, October (Isbister).—Good Words, October (Isbister).—Records of the Geological Survey of India, Vol. xxvii. Part 3 (Calcutta).—Popular Astronomy, September (Wesley).

## CONTENTS.

PAGE
**Another Substitute for Darwinism. By Dr. Alfred R. Wallace, F.R.S.** . . . 541
**The Mean Density of the Earth** . . . 542
**Mining. By Bennett H. Brough** . . . 543
**Dr. Adler's Observations on Gall Flies. By W. F. K.** . . . 545
**Our Book Shelf:—**
  Notter and Firth: "Hygiene" . . . 545
  Reynolds: "Primer of Hygiene" . . . 545
  Macpherson, Stuart-Wortley, and Saintsbury: "Fur and Feather Series.—The Grouse" . . . 546
**Letters to the Editor:—**
  Has the Case for Direct Organic Adaptation been fully stated?—**H. M. Bernard** . . . 546
  The Great Nebula in Andromeda. (*Illustrated.*)—**C. Easton** . . . 548
  On the Identification of Habitual Criminals by Finger-Prints.—**Henry Faulds** . . . 547
  The Tetrahedral Carbon Atom.—**Dr. G. S. Turpin.** 547
  Careless Writing.—**F. G. Donnan** . . . 549
**On the Doctrine of Discontinuity of Fluid Motion, in Connection with the Resistance against a Solid moving through a Fluid. II. By Lord Kelvin, P.R.S.** . . . 549
**Mr. Scott Elliot's Ruwenzori Expedition. By W. T. Thiselton-Dyer, C.M.G., F.R.S.** . . . 549
**The Physiological Action of the Paraffin Nitrites** . 550
**The Late Professor J. P. Cooke** . . . 551
**Notes** . . . 552
**Our Astronomical Column:—**
  An Instrument for Photographing Meteors. (*Illustrated.*) . . . 556
**Sun-spot Observations at the Potsdam Observatory. By W. J. L.** . . . 556
**Physics and Engineering at the McGill University, Montreal. (*Illustrated.*)** . . . 558
**Societies and Academies** . . . 564
**Books, Pamphlets, and Serials Received** . . . 564